INVESTIGATING THE EFFICACY OF AEROBIC AND BREATHING EXERCISE ON NEUROCOGNITIVE, PULMONARY AND AUTONOMIC FUNCTIONS IN SMOKERS

SHORT SYNOPSIS

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Preeti Saini
Registration number: MRIIRSPHD23/01857

Under the supervision of

Professor.Dr. Nitesh Malhotra

SCHOOL OF ALLIED HEALTH SCIENCES

MANAV RACHNA INTERNATIONAL INSTITUTE OF RESEARCH AND STUDIESSECTOR-43, SURAJKUND – DELHI ROAD, FARIDABAD - 121001

SCHOOL OF ALLIED HEALTH SCIENCES

Certificate

I hereby declare that the short synopsis **"Investigating the Efficacy of Aerobic and Breathing Exercise on Neurocognitive, Pulmonary and Autonomic Functions in Smokers"** being submitted in fulfillment of the requirement for the degree of Doctor of Philosophy in the Department of Physiotherapy under School of Allied Health Sciences of Manav Rachna International Institute of Research & Studies, Faridabad during the academic year 2024-2025.

It is a bona fide record of original work carried out under the supervision of **Dr. Nitesh Malhotra** and has not been submitted in full or part to any other university or institute for degree or diploma. Further, it is certified that Short Syposis is plagiarism free and proof has been submitted.

Preeti Saini
Registration No.: 22/Ph.D/082
ORCID ID: 0000-0001-6393-3797

19/1/2025

Signature of Supervisor
Dr. Nitesh Malhotra
Professor, Department of Physiotherapy
School of Allied Health Sciences

19/1/2025

Dr. Nitesh Malhotra
Professor, Department of Physiotherapy
School of Allied Health Sciences
(Chairperson, DRC)

Dr. Puneet Batra
(Dean, School of Allied Health Sciences)

ABSTRACT

Background: Smoking is a considerable factor for dysfunction in neurocognitive, pulmonary, and autonomic functions. Smoking, being the most significant health burden these days, is still unexplored. Researchers in previous research mainly used pharmacological approaches, but they also employed nonpharmacological methods to mitigate the adverse effects of smoking. Aerobic and breathing exercise programs show a beneficial impact on improving dysfunctions. But there is a dearth of studies that have extensively analyzed the effectiveness of smoking and a comprehensive program to overcome these problems.

Aim: This study aims to assess the impact of smoking and compare the effectiveness of aerobic exercises versus breathing exercise programs on neurocognitive, pulmonary, and autonomic function.

Materials and Methods: An observational study was conducted, which evaluated the impact of smoking on neurocognitive, pulmonary, and autonomic functions among smokers and nonsmokers. Subsequently, an experimental study focused on smokers with identified dysfunctions to evaluate the effectiveness of breathing and aerobic exercise interventions in improving these functions. A total of 500 smokers were observed for dysfunction. From this cohort, 130 smokers exhibiting significant dysfunction were randomly assigned into two intervention groups of 65 each—one for aerobic exercise and the other for breathing exercises after meeting inclusion and considering exclusion criteria. The protocol of the exercises was performed for 5 weeks, where both pretest and posttest measures were recorded for both groups.

Results: The findings revealed that smoking has a substantial influence on neurocognitive, pulmonary, and autonomic functions. Aerobic and breathing exercise interventions significantly improved neurocognition, pulmonary, and autonomic function($p \leq 0.001$). Nonetheless, there existed no discernible difference in the effectiveness of the two intervention groups that was statistically significant.

Conclusion. In conclusion, both aerobic and breathing exercises significantly improved neurocognitive, pulmonary, and autonomic functions in smokers, with minimal differences in efficacy between the two. These findings advocate for a patient-centered approach to intervention selection, emphasizing consistent practice rather than the type of exercise alone.

Keywords: Autonomic dysfunction, cognitive dysfunction, Pulmonary dysfunction, smokers

CHAPTER 1

INTRODUCTION

INTRODUCTION

Smoking is found to have a direct and foremost impact on the quality of life (QOL) and life expectancy, with changes in mortality and morbidity. (Alanazi et al., 2023)Further with frequent environmental exposure and smoke inhalation might be injurious to health. Smoking is a significant risk factor for various non-communicable diseases and is the leading cause of morbidity and mortality for millions worldwide.. Smoking became the leading factor behind mortality and disease burden by causing 6.4 million deaths, with an average of six deaths per second and 168 million disability-adjusted life years globally (Erickson et al., 2009; Ren et al., 2019). WHO estimates that tobacco smoking kills up to half of its users and causes more than 8 million deaths each year around the world. This makes it the most preventable cause of mortality. According to statistics, 21.2% of individuals smoke, which means that smoking prevalence is still high worldwide (35.8% of men and 6.6% of women) (Al-Mshari et al., 2020)Bipolar disorder (55–70%), major depressive disorder (40–60%), and schizophrenia (44–88%) are among the mental illnesses where smoking is most common. According to Besson et al. (2016), smoking appears to be common among substance users, including those who use alcohol (50–70%), cocaine (70–80%), and opioids (90%). According to disability-adjusted life years (DALYs), smoking was the second-highest risk factor. There has long been a correlation between smoking and a higher risk of lung cancer and other respiratory diseases. Cigarette smoking is a common, dangerous habit. It is linked to the early onset and quick development of chronic illness in middle age (Ng et al., 2020). Cigarette smoking has recently been found to be the second most important risk factor for non-communicable diseases, which is leading to mortality due to increasing incidence related to cancer, heart disease, chronic lung disease, and diabetes. Diabetes mellitus, cancer, cardiovascular disease, and chronic obstructive pulmonary disease (COPD) constitute the predominant smoking-related mortality. However, there is limited understanding of the fundamental pathways and their impact on the risk of neuropsychiatric disorders.(Drope et al., 2018; Hamasaki, 2020). Smoking is found to be associated with an elevated risk of Pulmonary Disorders in almost 50% of all smokers (Sanchez et al.,2020)

Role of Smoking on Pulmonary Function

Smokers show a higher prevalence and an increased incidence of respiratory symptoms, a faster yearly drop in lung function and FEV_1, and a higher death rate from COPD than non-smokers.. (Simmons et al., 2005)Tobacco smoke consists of various poisonous substances,

while burning tobacco, various chemical reactions like pyrolysis, prosynthesis, distillation, sublimation, hydrogenation, oxidation, decarboxylation, and dehydration can take place, which produces more than 4000 compounds. The produced smoke consists of a fine aerosol predominantly depositing on the airways and lung alveolar surface (Tantisuwat et al., 2014). It disturbs the respiratory airways' function, tars irritate bronchial epithelium, and nicotine increases heart rate and elevates systolic blood pressure (Tantisuwat & Thaveeratitham, 2014). Consumption of tobacco smoke. When you smoke tobacco, irritant receptors make smooth muscles tighten, which makes the airways suddenly more resistant for an hour.. Smoking for a prolonged period may affect ciliary movements, inhibit the actions of alveolar macrophages, and pave the path for hypertrophy and hyperplasia of mucosal glands.In recent research, researchers showed how smoking affected adults' pulmonary function (Nasir, 2024). Smoking decreased pulmonary function as measured by Forced Vital Capacity, Forced Expiratory Rate in first, Second, and ratio between FEV_1/FVC, FEF25-75%, or forced expiratory flow, at 25-75%. The smoking relationship with factors like the relationship between daily cigarette consumption, age, smoking duration, and pulmonary function has been assessed and it is found to be positively associated with pack years, means that increase in pack year after 15 years is leading to sharp and rapid decline in pulmonary function in smokers(Rawashdeh & Alnawaiseh, 2018)**. Though various researchers have studied pulmonary function, there is still literature lacking about the role of exercise on pulmonary function**

Role of Smoking on Cognitive Functioning

Smoking has a well-documented relationship with the brain and numerous possible adverse effects on the brain, including cognitive functions like motor capabilities, attention, and memory, dementia, and Alzheimer's disease (Barnes & Yaffe, 2011). It may hamper memory functioning and sleep quality. Smoking also reduces life expectancy by 20-25 years, along with severe comorbid psychiatric illness (Holford et al., 2014)

Nicotine is an addictive substance used in cigarettes. Smokers relate smoking to increased alertness, concentration, and gross mental performance. But it has specific neurotoxic effects and is related to a heightened risk of developing cognitive impairment, though the role of smoking on cognitive functioning is still contradictory (Pushpa et al.,2019). People with cognitive impairment are more vulnerable to tobacco-induced death and have quite a difficulty in smoking cessation (Besson et al.,2016).

Numerous causes examined by meta-analyses of prospective studies provide strong evidence for the link between smoking and dementia or cognitive decline. The meta-analysis of nineteen studies examining the association between smoking and dementia, as well as cognitive impairment in older adults, also showed that increased smoking increased the risk of Alzheimer's disease, vascular dementia, and any dementia by 79%, 78%, and 27%, respectively (Hahad et al., 2021). It was observed that greater yearly cognitive declines occurred, which were found in follow-ups among current smokers as compared to former smokers and non-smokers. In good agreement, a more recent meta-analysis done on thirty-seven studies prospectively studied and showed that an increased risk of all causes of mental problems like dementia, Alzheimer's disease, and vascular dementia in smokers (Zhong et al., 2015). Current smokers have a higher risk of cognitive decline compared with ''former and never' 'smokers (Zhong et al., 2015). Vascular influence on cognitive decline and dementia consists of structural and functional variations in blood vessels associated with decreased neurocognitive results. Smoking may indirectly elevate the risk of acquiring cognitive decline by accelerating the likelihood of vascular disease(Lewis et al., 2021). Chronic smoking is linked with cognitive deterioration, depending upon the brain atrophy, which progresses quickly among smokers in contrast to non-smokers, which can be visualized through brain neuroimaging(Besson & Forget, 2016; Grabowski et al., 2020). Further, Nicotine reduces the default-mode network's activities and enhances executive control areas within the brain (Sutherland et al., 2017).Smoking has had a negative relationship with learning (Lewis et al.,2021); they have conceded that smoking leads to more learning problems among women and more cardiovascular problems in men.Various techniques can improve performance and learning in person, with Cognitive problems like CBT, Physical Activity, and Breathing Techniques.

Abrantes studies that the acute effect of aerobic exercises is to decrease anxiety, mood elevation, and reduced craving after 4 to 8 weeks of exercise(Abrantes et al., 2018)

Aerobic exercises are associated with improved motor praxis, vasomotor organization, attention, concentration, and thinking operations, and 24 weeks of exercises(Alghadir et al., 2016) Physical activity decreases damage in the grey matter due to smoking and aging, which is thought to be a matter(Erickson et al., 2009).In this continuation, some research has given a concrete idea that aerobic exercise increases the release of brain-derived Neurotrophic factor, also facilitates the blood flow to the brain (Hötting et al., 2016), thus increasing the availability of food and substrate to the brain, thus reducing aging-related and smoking-related damage.

Rabbitt has studied the effect of Aerobic training on various cognitive parameters of older adults (Rabbitt et al., 2004). Though there exist relationship between exercise and cognition has been studied, to the best of our knowledge, there is a lack of literature comparing aerobic and breathing exercises on neurocognition in smokers.

Role of Smoking on Autonomic Functioning

Tobacco smoking is known as the prime reason for autonomic imbalance due to its sympathoexcitatory nature. Nicotine leads to the potential release of catecholamines. These catecholamines and other smoke particles from cigarette burning of organic matter pave the path for an imbalance between the sympathetic and parasympathetic systems (Irfan, 2019)Additionally, research has demonstrated that non-smokers have a higher resting HF (High Frequency) than smokers, suggesting smoking impairs the vagus nerve's regulatory functions during rest (Eryonucu et al., 2000). Smoking can easily affect how the parasympathetic nervous system works since both short-term and long-term smokers are at risk of having a sudden or brief loss of vagus cardiac regulation. Additionally, recent studies have shown that heavy smokers' autonomic nervous systems have impaired regulatory capacities, which may be a significant risk factor for cardiovascular disease in smokers (Barutcu et al., 2005).

Role of exercises on cognitive functioning, pulmonary, and autonomic functions

Exercises play a critical and important role in the vital functioning of the Central Nervous System (CNS) by enhancing resistance against several neurological impairments. It can enhance mental health by slowing the progression of cognitive delay and other psychiatric illnesses(Gomez-Pinilla & Hillman, 2013). Acute exercise facilitates brain areas responsible for cognitive and motor processes.

Recent research has examined the significant positive effect of aerobic physical activity (APT) on Neuronal and brain health and cognitive functioning in both healthy and neurocognitively impaired individuals (Mandolesi et al., 2018). These exercises were created to improve treatment results by promoting neural plasticity. This method, which has been dubbed "exercise priming," is a relatively recent development in motor control and exercise science (Moriarty et al., 2019). There is an intrinsic relationship between exercise and energy metabolism. Energy metabolism at the cell level is related to synaptic plasticity and neuronal excitability. Mitochondria are necessary for assisting neuronal signaling via the plasma membrane. Thus, molecular systems like brain-derived neurotrophic factor (BDNF) play a key role in enhanced cognitive functioning induced by exercise (Gomez-

Pinilla & Hillman, 2013). The benefits and Physiological effects of exercise in the older population include improved arterial compliance, energy metabolism, endothelial function, quality of sleep, and muscle mass/strength. It also promotes global vascular health and cardiovascular fitness by improving and increasing cerebral blood flow and middle cerebral artery vasodilation responses, which might aid in preventing or delaying additional illnesses that increase the risk of cognitive decline (Kruger et al., 2021). Physical activity at high level has positively impacted the cognitive function in middle-aged individuals aged between 54 to 65 years and older 65 years. Acute APT resistance training can help improve executive function deficits and enhance overall physical performance, which are linked to better neurocognitive outcomes (Tsai et al., 2018). Increased fitness level can be related to bilateral hippocampal volume, and enhanced spatial memory performance implies that aerobic fitness effectively prevents age-related cortical and cognitive decay (Erickson et al., 2009). Both acute and chronic APT can modulate the brain's motor and cognitive abilities, providing a stable framework for designing and prescribing the APT (Moriarty et al., 2019).

The APT can also potentially promote mucociliary clearance functions. A significant improvement was reported in the clearance of radioactive matter among non-smokers following 30 min APT on a stationary bicycle. It also increases sympathetic activity and circulating catecholamine levels (Ramos et al., 2015).

The deep breathing exercises are extempolary important to improve pulmonary function and saturation in smokers by increasing inhalation and exhalation. These techniques are even emphasized to relieve stress and help them quit smoking. Even recent research has emphasized that diaphragmatic breathing techniques decrease breathing rate, which, in turn, decreases breathing work and reduces oxygen demand (Hamasaki, 2020). Still, there is a dearth of studies that compare various exercise forms to improve decremented parameters in smokers.

It is evident that aerobic exercises and breathing exercises are a practical and established choice of modality to improve Pulmonary function, Autonomic function, and cognitive function in smokers (Erickson et al., 2009). However, a Paucity of Studies has compared and studied the effectiveness of these two exercise programs in improving the smokers' neurocognitive, autonomic, and pulmonary status.

1.1 Aim

This study aims to assess the impact of smoking and compare its effectiveness of aerobic exercises versus breathing exercise programs on neurocognitive, pulmonary, and autonomic function in smokers.

1.2 Objectives

Phase I

(i)To study the impact of smoking on neurocognitive function among smokers.

(ii)To study the impact of smoking on pulmonary function in smokers.

(iii)To study the impact of smoking on autonomic function among smokers.

(iv)To compare the neurocognitive, autonomic & pulmonary function among smokers and nonsmokers

Phase II

(i)To study the efficacy of aerobic exercise on neurocognitive, pulmonary& autonomic function in smokers.

(ii) To study the effect of breathing exercises on smokers' neurocognitive, pulmonary& autonomic function.

(iii)To compare the effect of aerobic versus breathing exercises on neurocognitive, pulmonary& autonomic function in smokers.

1.3 Hypothesis

1.3.1 Experimental hypothesis

Phase 1

(i). There will be a statistically significant effect of smoking on neurocognitive functions among smokers.

(ii). There will be a statistically significant effect of smoking on pulmonary function among smokers.

(iii). There will be a statistically significant effect of smoking on autonomic function among smokers.

(iv). There will be a significant difference between neurocognitive, pulmonary, and autonomic function amongst smokers and nonsmokers.

Phase II

(i). There will be a statistically significant effect of aerobic training on neurocognitive, pulmonary and autonomic function.

(ii). There will be statistically significant effect of breathing training on neurocognitive, pulmonary and autonomic function.

(iii). There will be significant difference between changes in neurocognitive, pulmonary and autonomic function compared with aerobic and breathing exercise in smokers.

1.3.2 Null hypothesis

Phase 1

(i). There will be no statistically significant effect of smoking on neurocognitive functions among smokers.

(ii). There will be no statistically significant effect of smoking on pulmonary function among smokers.

(iii). There will be no statistically significant effect of smoking on autonomic function among smokers.

(iv). There will be no significant difference between neurocognitive, pulmonary, and autonomic function amongst smokers and Nonsmokers.

Phase II

(i). There will be no statistically significant effect of aerobic training on neurocognitive, pulmonary and autonomic function.

(ii). There will be no statistically significant effect of breathing training on neurocognitive, pulmonary and autonomic function.

(iv). There will be a significant difference between changes in neurocognitive, pulmonary, and autonomic function compared with aerobic and breathing exercise in smokers.

1.4 Significance of the study

Nearly 267 million Indian adults (29%) use tobacco, making smoking a significant health burden in developing countries (Shaikh & Saikia, 2022). Despite its pervasiveness, little is known about how smoking affects pulmonary, autonomic, and neuropsychological processes. Investigating these relationships is essential given India's distinct lifestyle and high smoking prevalence. The purpose of this study is to determine how smoking affects various health areas and how well physiotherapy interventions—specifically aerobic and breathing exercises—work as economical management techniques.

In this line of thought, the present study was directed toward studying the changes in neurocognition and pulmonary autonomic functions among smokers and testing the effectiveness of physiotherapy programs like aerobic and breathing exercises for coping with these health issues**.**

1.5 Operational Definitions of the Variables

Current smoker: An adult who has smoked 100 cigarettes in their lifetime and who currently smokes cigarettes. According to the NHIS Centre for Disease Control (Jamal et al., 2015)

Former smoker: An adult who has smoked at least 100 cigarettes in their lifetime but who had quit smoking at the time of the interview. According to the NHIS Centre for Disease Control(Jamal et al., 2015)

Non-smoker: An adult who has never smoked or has smoked less than 100 cigarettes in their lifetime. According to the NHIS Centre for Disease Control(Jamal et al., 2015)

Number of pack-years = (number of cigarettes smoked per day/20) × number of years smoked. •

- 0–10 pack-years =1
- 11–20 pack-years =2
- 21–30 pack-years = =3

Neurocognitive/Cognitive function- This study defines neurocognition as cognitive domains: attention and concentration, executive functions, memory, language, visuo-constructional skills, conceptual thinking, calculations, and orientation.

Neuro Cognitive dysfunction -According to MOCA version 8.3, Cognitive dysfunction is defined as individual with an MOCA score of 26/30.

Pulmonary Function: -Pulmonary function tests (PFTs) in this study are defined as the procedure to evaluate the respiratory function of adults (American Thoracic Society guideline). They are reproducible and accurate.

Pulmonary Dysfunction: According to American Thoracic Society guidelines, we are taking pulmonary dysfunction as individuals with mild to moderate COPD **(**≥ 50% and ≤ 80%**)**

Autonomic Function is the relationship between the Parasympathetic and sympathetic nervous system functions. Analysis of HRV frequency components (LF ≤500 Hz >1200 Hz and HF ≤300 Hz) Shaffer, F., & Ginsberg, J. P. (2017)

CHAPTER- 2

REVIEW OF LITERATURE

2. Literature Review

2.1. Effect of Smoking on Cognition

Various researchers have studied cognition and smoking, and they have explicitly studied its role in nicotine, nicotine receptors, and the relation to pack years. Also, acute and chronic effects have been studied. The effect of smoking has been studied by :

(Ernst et al., 2001) Evaluated cognitive activation while performing a memory task in twenty-two abstinent and former smokers. They were administered a placebo gum and a 4 mg nicotine gum. The outcomes on 2BT did not vary between the groups of smokers. In the placebo group, ex-smokers demonstrate significant activations in the left and right hemispheres in smokers. Activation was increased in ex-smokers but decreased in smokers when nicotine was given. The lateralisation of activation as a result of nicotine dependence implies that cognitive processes utilised to complete the memory task are impacted by long-term exposure to or removal from nicotine. The authors modified a working memory test and PET that visualises regional brain function in order to clarify the neuroanatomical underpinnings of nicotine's effects on cognition.

(Ott et al., 2004) Prospectively studied the impact of smoking on cognition in elderly non dementia individuals. The annual average reduction in Mini-Mental State Examination (MMSE) scores was analyzed between groups, controlling for age, sex, baseline MMSE, type of habitation, education, and history of myocardial infarction or stroke. The average MMSE score of individuals for non-smokers has significantly decreased by 0.03 points per year. The adjusted decrease for past smokers was 0.03 points higher, and for present smokers, it was found to be 0.13 points higher than that of non-smokers ($p \leq 0.001$). Increased rates of decline were found in both genders who smoked, those with and without a familial history of dementia, and across three of the four studies in research. A greater exposure to tobacco pack-years was associated with a markedly increased rate of deterioration.

(Nooyens et al., 2008) Investigated the influence of smoking on cognitive impairment over five years among 1964 middle-aged people (43-70 years), through a Cohort Study. They were examined for the cognitive ability of participants at baseline and after one year. The study findings indicate a 1.9-fold increase in memory impairment and diminished cognitive

function compared to never smokers. The deterioration in all cognitive domains escalated with the rising quantity of packets smoked annually.

(Cysique et al., 2011) Investigated cognitive performance in a cohort aged 43 to 53 years and studied the effects of cigarette smoking on midlife cognitive performance. The study reported that smoking was associated with verbal memory declines and slower visual search speeds. These changes were reported in both sexes and independent of socioeconomic level, prior (adolescent) cognitive ability, and a variety of health indicators, and there was cognitive decline in individuals who smoked more than twenty cigarettes per day. Variations in blood artery structure and function linked to poorer neurocognitive outcomes comprise the vascular influence on dementia and cognitive decline. By increasing the risk of vascular illness, smoking may indirectly increase the chance of developing cognitive deterioration.

(Lewis et al., 2021) Using a cohort of 70,000 individuals ages 18 to 85, we assessed the association between verbal learning and memory capacity and gender, smoking, and cardiovascular disease. Across a broad age range, they discovered that smoking is linked to cardiovascular illness more in men and verbal learning performance more in women.

(Xia et al., 2019)demonstrated the association between brain-derived neurotrophic factor (BDNF) and nicotine addiction among 620 Chinese, among whom 322 were smokers. The circulating BDNF is a biomarker of memory and cognitive function. Their findings suggest that smoking is associated with cognitive impairment in Chinese people and appears to be dependent on the BDNF-Val66Met polymorphism.

(Vermeulen et al., 2018). The objective of this research is to comprehensively study and prospectively assess the multi-cross-sectional relationship between smoking attitude and performance on specific cognitive items. An association between changes in smoking behavior and cognitive functioning in smokers was longitudinally established by the study. This research study was conducted, which is a cohort study in which patients with non-affective psychosis and their siblings were compared with healthy control subjects. In comparison to the non-smoking participants and the non-smoking controls, a correlation was observed between smoking and a decrease in speed of processing in the patient and control groups. The Composite International Diagnostic Interview was employed to evaluate smoking behavior at baseline, as well as at the third and sixth years. A test battery was administered to evaluate cognitive

functioning. At the outset, 66.6% of the patients were smokers, while 38.3% of the siblings and 25.2% of the controls were not. In comparison to the non-smoking participants and the non-smoking controls, the patient and control groups reported significant associations between smoking and decreased processing speed. Smoking was considerably associated with decreased working memory and reasoning, as well as problems, among siblings in comparison to non-smokers. The research suggests that smoking is associated with inferior cognitive ability in patients and also a decline in cognitive ability in their siblings and healthy control subjects compared to non-smokers. Their processing efficiency may be enhanced through smoking cessation.

The study done by Puspha et al investigated the effect of smoking on the cognitive functioning among Indian young adults **Pushpa et al. (2019)** assessed and compared the cognitive functioning of 30 male smokers against 30 male non-smokers. A self-reported questionnaire was distributed to them, which detailed their personal history and smoking habits. The scores of the cognitive tests were tabulated and analyzed for the samples of both categories. In comparison to the control group, smokers exhibited a substantial decrease in sustained attention ($P \leq 0.001$) and psychomotor speed ($P \leq 0.001$). However, no significant changes in executive functions were observed with decreasing velocity.

(Al-Mshari et al., 2020) Investigated the relationship between cognitive function and cigarette smoking, and found that plasma brain-derived neurotrophic factor (BDNF) levels in a sample of 73 healthy young adults, including 31 smokers. The participants' cognitive function was evaluated using the Cambridge neuropsychological test automated battery (CANTAB). Blood samples were collected to assess the plasma levels of BDNF, concluding that the plasma BDNF level is positively correlated with the daily number of cigarettes smoked. Adolescents who smoke exhibit notable deficiencies in sustained attention and demonstrate a reduced capacity to handle conflicting information when contrasted with their non-smoking peers of the same age.

Recently, **(Grabowski et al., 2020)**proposed that cigarette smoking and depression exist with mild cognitive disorders. They studied 43 people with mild cognitive impairment who were assessed through ADAS-Cog at baseline and 2 years later. Participants with scores of eighteen or higher on the MADRS were classified as depressive, while the Fagerström scale

for nicotine dependence was utilized for smokers. The findings indicate a correlation between the intensity of depressive symptoms and a decline in cognitive functions, with smoking also linked to the severity of depressive conditions. Their findings indicate that nicotine dependency should not be viewed as a sole contributor to the emergence of mood disorders and the advancement of cognitive decline.

There is a depth of studies regarding the relationship between increased smoking frequency and cognitive decline; therefore, the study will concentrate on examining the effects of smoking on cognition.

2.2 Role of Exercises on Cognitive functions in smokers

Research provides substantial data indicating the correlation between physical activity and the efficacy of aerobic training regimens in identifying and controlling cognitive decline and dementia. However, as per the previous studies, these interventions influence cognitive health and structural changes in the brain, and it continues to be a matter of discussion regarding impairment progression.

(Erickson et al., 2009)studied the association between aerobic fitness levels with hippocampus volume and spatial memory in 165 nondemented older people. They visualised hippocampus volume through MRI and spatial memory through a spatial memory task on a monitor. The aerobic fitness level was determined through maximal graded exercise testing on a motor-driven treadmill with respiration. Authors observed a triple association, saying increased fitness levels were closely related to greater bilateral hippocampal volumes, which were then correlated with better spatial memory execution.

(Sofi et al., 2011)A total of 15 prospective cohort studies was analyzed, tracking over 30,000 healthy older adults for a duration of 1 to 12 years. Those who engaged in higher levels of physical activity prior to the follow-up period experienced a 38% lower risk of cognitive decline when compared to individuals with a sedentary lifestyle at the outset.

A single-blinded RCT performed by**(Bhatia et al., 2017)** investigated effect of yoga training (YT) and effect of physical exercise training (PET) in improving the cognitive ability of 286 clinically stable adult schizophrenic patients. They were randomly allocated into treatment as usual (TAU), YT with TAU, or PET with TAU. For evaluation of the speed index the cognitive domain of the Penn computerized neurocognitive battery is been used is been calculated at the baseline , 21 days, and 3 and 6 months after the training. The results indicate that YT and PET exhibited significant improvement at the 6-month follow-up ($p \leq 0.036$, with an effect size of 0.51). The PET group exhibited significantly greater improvements in the attention domain

relative to TAU alone following the sixth month ($p \leq 0.025$ with an effect size of 0.61). Further cognitive assessments indicate significant benefits associated with Yoga Training or Physical Exercise training in contrast to TAU alone ($p \leq 0.05$, effect values between 0.30 and 1.97). Consequently, the author determined that both YT and PET enhance attention and various cognitive areas following training, suggesting that as supplementary methods, YT or PET can be advantageous for individuals with SZ.

Aerobic training for Cancer-related cognitive impairment (CRCI) may positively impact cognitive function. **(Peterson et al., 2018)** investigated the viability of an intervention combining aerobic and cognitive training to assess its impact on cognitive functions among 28 participants who are undergoing cancer treatment. There were tests of both physical and mental abilities before and after the intervention. There were 36 sessions on virtual game-based cognitive exercises (COG), a Second group performed aerobic exercise (AER), a third group performed cognitive exercise, and a combined aerobic exercise group (AER + COG), and flexibility (CON) training. This lasted for about 12 weeks. Within-group measures showed that all scores went up, except for all cognitive scores (AER + COG and COG groups).

(Tsai et al., 2018) Sixty older persons diagnosed with amnestic moderate cognitive impairment (aMCI) were recruited and randomly allocated to one of three groups to three groups that is Group A Aerobic exercise (AE) Second Group B resistance exercise (RE), Group C is non-exercise control group. The study sought to assess the impacts of aerobic exercise (AE) and resistance exercise (RE) on neurocognitive performance and molecular markers of executive function tasks in older persons with amnestic mild cognitive impairment (aMCI). It also examined the correlation between acute exercise-induced neurocognitive modifications and variations in circulating neuroprotective growth factors triggered by diverse exercise modalities.At baseline and during a single 30-minute session of moderate-intensity exercise, individuals performed the Flanker task, facilitating the concurrent evaluation of behavioral outcomes and electrophysiological measures.Blood sample collection was done at three stages i.e. before , During and after the post-exercise cognitive evaluation. The findings demonstrated that both AE and RE significantly elevated ERP P3 amplitudes and enhanced behavioral performance. There were no significant changes in serum FGF-2 levels after either form of exercise. But acute exercise tended to raise VEGF levels and caused big rises in BDNF and IGF-1 levels.

(Stern et al., 2019) Investigated the effectiveness of aerobic exercise programs on cognitive function. They have conducted a randomized trial and suggested that aerobic exercises improve cortical thickness and brain health.

(Sexton et al., 2020) Examined the impact of 12 weeks of aerobic training programs versus a control group exercise program on cardiorespiratory fitness, cognitive function, and magnetic resonance imaging (MRI) outcomes in a pilot study including forty-six healthy older individuals. Maximum Ventilatory oxygen consumption is used to evaluate the Cardiorespiratory fitness, which was also complemented by cognitive measures, especially executive function, memory also on processing speed. The MRI structural investigation included an examination of the volume of the hippocampus and an assessment of voxel-wise grey matter volume utilizing voxel-based morphometry. Diffusion tensor imaging was also employed to analyze fractional anisotropy, axial diffusivity, and radial diffusivity using tract-based spatial statistics. There was no evidence that the aerobic training program affected cognitive functioning or brain anatomical measurements in older adults, although the intervention was effective in improving cardiorespiratory fitness. Outcomes from multifactorial therapies that are more enduring or targeted at certain high-risk populations may be a significant improvement in the targeted population. Though ample literature is present on the role of aerobic exercises on cognition, controversy exists on the role of aerobic exercise on cognition, so more studies are needed to determine improvement in cognitive functions.

2.3 Role of Smoking on Pulmonary Function in Smokers

Pulmonary Function Tests (PFTs) were developed to test how well the lungs work and are recommended for those who are having trouble breathing. There is a strong link between smoking and a decline in lung function. Smokers have a higher risk of acquiring respiratory symptoms, lung function problems, and a faster yearly drop in FEV1, with a higher rate of morbidity and mortality found in Smokers versus non-smoker controls.

(Liu et al., 2018) Smokers have a considerably lower FEV to FVC ratio. So, it is quite helpful to quickly find out what is wrong with adult smokers. After measuring the various lung volumes, including total Lung capacity, Residual Volume, and impacting values like airways resistance, Static and Dynamic compliance of lungs, and the alveolar plateau. The conventional spirometric variables measured while breathing air or a helium and oxygen mixture for 86 smokers and 100 individuals who never smoked were evaluated through pulmonary Function Testing. After the evaluation, the majority of the individuals aged between 20 and 70 who smoked heavily had PFT values that were impaired, whereas for the opposite group, airway resistance, volumetric airway conductance, volume of closure in Phase III, FEV_1/VC, volume of isoflow, and also mean transit time were raised.

(Neder et al., 1999)prospectively investigated and indicated that cigarette smoking significantly contributes to the development of various diseases, including malignancies, cardiovascular disorders, and respiratory conditions such as chronic obstructive pulmonary disease (COPD). In developing nations such as India, it continues to pose a significant public health challenge because of its contribution to rising morbidity and mortality rates. In smokers, spirometric assessments frequently indicate a reduction in essential lung function metrics. A cross-sectional research was carried out at a healthcare institute in Greater Noida, involving 200 healthy, asymptomatic male participants—100 smokers and 100 nonsmokers. Pulmonary function testing was conducted utilizing the RMS Helios 401, which prospectively examined the pulmonary functions of 100 non-smoking individuals aged between 20 and 80. A linear prediction model with equation analysis is utilized for gender-specific outcomes, derived through multiple regression analysis that includes inspiratory capacity (IC) along with residual volume (RV) ratio of RV/TLC ratio and total lung capacity (TLC), functional residual capacity (FRC), Even demographic parameters like age, height, weight, and body mass index (BMI) as utilised for predicting respiratory function by predictive models Basic demographic and anthropometric characteristics were equally useful as more complex measurements in predicting LV values, irrespective of gender and age. the expected effect of respiratory health problems.

(Mistry et al., 2014)assessed the impact of smoking on pulmonary function. The objective is to examine the variations in pulmonary function test values between 51 smokers and 54 non-

smokers in India. The PFT values, encompassing expiratory flow volume curves, were documented, and FVC, FEF, PEFR, FEV, and the FEV_1/FVC ratio were derived. The parameters of pulmonary function testing, including FVC, FEV, PEFR, FEF, and MVV, showed a significant reduction in smokers ($p \leq 0.05$).

(Represas-Represas et al., 2016) studied the validity and reliability of 6 portable PFTs used in COPD, which were used to check for COPD in 436 chronic smokers who smoked more than 10 packs a year. The study was set up as a prospective cohort design to test its validity and reliability. The COPD-6 device measured the PFT scores FEV1, FEV6, and the FEV1/FEV6 ratio. The individuals also underwent standard spirometry. They determined that the COPD-6 device is an effective instrument for COPD screening, with an optimal cut off point of FEV1/FEV6 ratio at 0.8 (sensitivity, 92.1%).

(Dutt et al., 2023) It has been observed that smoking cigarettes remains as a major cause of many ailments , including lung cancer, cardiac problems, and lung ailments including chronic obstructive pulmonary disease (COPD). In developing nations such as India, this issue continues to pose a significant public health challenge because of its contribution to rising morbidity and mortality rates. In smokers, spirometric assessment frequently indicates a reduction in essential lung function metrics. This cross-sectional study was carried out at a tertiary healthcare center in Greater Noida, involving 200 healthy, asymptomatic male participants—100 smokers and 100 nonsmokers. The RMS Helios 401 spirometer was utilized for pulmonary function testing in accordance with the guidelines set forth by the American Thoracic Society (ATS). Participants were selected on the basis of inclusion and exclusion criteria, and the data were analysed utilizing Epi Info 7 software. The analysis revealed no notable variations in average age or initial physical parameters between the two groups. Nonetheless, the spirometry findings indicated that individuals who smoke exhibited markedly lower values of Forced Vital Capacity along with Forced Expiratory Volume in the first Second, and ratio between FEV_1/FVC and also peak expiratory flow rate (PEFR), and forced expiratory flow (FEF) in comparison to those who do not smoke. Furthermore, a heightened smoking index—determined by multiplying the duration of smoking in years by the daily cigarette consumption—was linked to significant deterioration in pulmonary function, akin to the impacts observed with increasing age. The results highlight that smoking can cause significant pulmonary impairment, even in individuals who do not exhibit symptoms. Consequently, regular spirometry assessments in smokers could enable the early identification of functional deterioration, which may help alleviate the future impact of respiratory health issues.

(Rawashdeh & Alnawaiseh, 2018) A study was done on forty-year-old males on Forced Expiratory Volume (FEV1), with the following other parameters: forced vital capacity (FVC) and maximum voluntary ventilation (MVV), in a cohort of 100 healthy 40-year-old adults resident in Jordan with a history of smoking. The mean estimated values for FVC, FEV1, and MVV were recorded as : 2.72 L ± 0.87, 1.56 L ± 0.80, and 82.28 L ± 10.60, respectively, for each parameter. These values are lower than the expected values of 3.92 L ± 0.55, 3.70 L ± 0.65, and 147.80 L ± 18.06, respectively, for each parameter. There is a strong link between lower FVC, FEV_1, and MVV values and age, and if someone has been smoking chronically. However, there is no strong link between lower values and how many cigarettes someone smokes each day. Consequently, the scientists concluded that aging and smoking may accelerate the decline of PFT values, which has significant implications for both smoking cessation and research focus.

(Dugral & Balkanci, 2019) Studied and explored pulmonary function. They studied variables like age, gender, weight, height, pulmonary symptoms, smoking status, and sports habits—552 females and 464 males. Smokers and nonsmokers have significant differences in sputum, wheezing, and the value of FVC and FEV_1, with more sputum and wheeze in smokers and better FEV1 and FVC in nonsmokers.

2.4 Role of Exercises on pulmonary function in smokers

(Koubaa et al., 2015) performed the study to evaluate the effectiveness of an aerobic interval exercise training program on various parameters of pulmonary function and aerobic capacity in subjects who consumed cigarettes and hukka. Relationship with the quantity of cigarettes consumed daily. In total, 12 cigarettes, 10 hookahs, and 11 smokers participated. All participants performed interval training of 30 minutes, with 2 minutes of work and 1 minute of rest at 70 percent, three times a week for 12 weeks. Pulmonary function was assessed pre- and post. There is no significant effect on pulmonary function in smokers and non-smokers. It has increased FEV1 and PEF in smokers. After twelve weeks, VO2 max and heart rate recovery index and resting heart rate decreased, altered lung function only partially, and improved aerobic capacity and life quality, emphasizing interval training.

(Ahmed et al.)studied the effect of an aerobic training program on pulmonary function in smoking university students. Fifty college subjects were randomized and assigned to the control and experimental groups. The experimental group performed aerobic training for

twelve weeks, for a duration of 40 minutes, three times weekly on alternate days, on a treadmill at 65-80% of HRR. Control group subjects didn't participate in the exercise program, before and after intervention, parameters like various Anthropometric parameters, peak oxygen consumption (VO2peak), and pulmonary function.

(Jun et al., 2016) performed a study on elderly smokers on pulmonary functions and muscle activation by use of Ballon-Blowing Exercises in two groups, i.e., the experimental group and the control group, where they were assessed for enhanced pulmonary function and muscle activation. For six weeks, the experimental groups completed workouts three times a week, whereas the control group did not do any exercises. The results reflected that in the eexperimental group, the effect of breathing exercise lasted for 15 minutes, whereas in the control group, after performing three sets of Balloon-Blowing Exercises (BBE) with intervals in between, showed improvements in lung function and an increase in the strength of the muscles, enhancing breathing comfort.

(Seo et al., 2015) Investigated and studied the impact of diaphragmatic exercises on pulmonary function in men smokers in their twenties, and explored the significance of diaphragmatic exercises. Participants were randomly assigned to experimental and control groups. Subjects in the experimental group performed thirty minutes of diaphragm respiration three times a week for a duration of four weeks, whereas the control group underwent exercises utilizing MOTOmed. Pulmonary function was assessed and analysed prior to and following the experiment, which demonstrated an increase in respiratory muscle strength. The experimental group showed improvement in the pulmonary function, and parameters were compared for tidal volume, inspiratory reserve volume, inspiratory capacity, and breathing capacity. The experimental group showed significant changes as compared to controls. The results demonstrate that the experimental group, performing diaphragmatic breathing exercises, showed a more pronounced improvement and changes in the pulmonary function as compared to the control group. Studies regarding the role of various exercises on lung function still have not given concrete thought to which technique to use to improve lung function, which remains debatable. More research needs to be done considering the need for the development of a programme to improve pulmonary function.

2.5. Role of Smoking on Autonomic function or Heart rate variability (HRV)

(Hayano & Yuda, 2019) Evaluated the immediate and persistent effects of cigarette smoking on HRV under monitored respiration (15/ min). Nine smokers without a history of cardiopulmonary diseases were evaluated after one night of cessation from smoking to determine the immediate effect.. The HRV decreased 3 minutes following the smoking of 1 cigarette, indicating activities mediated by the sympathetic nervous system, which intensified after 10-17 minutes. Simultaneously, a total of 81 participants (25 non-smokers, 31 moderate-smokers consuming 1-24 cigarettes per day, and 25 heavy-smokers consuming more than 25 cigarettes per day) who underwent overnight abstinence were evaluated to examine the long-term effects. The intensity of the Mayer wave did not change according on smoking status, but the respiratory component was much lower in young heavy smokers (≤30 years) than in young non-smokers or moderate smokers who were lying down. Moreover, after evaluating the results it was observed that there was an decrease in the pulmonary functions and resiprocal changes were observed in Mayer wave component, These changes were more evident in non-smokers as compared to heavy smokers. An immediate and momentory reduction in the vagal activity and cardiac regulation, while heavy smoking is associated with a lasting reduction in VCC among younger individuals.

(Sajadieh et al., 2004)A study was conducted involving middle-aged individuals (n = 643), all of whom were healthy. A baseline physical examination, fasting laboratory tests, "C-reactive protein (CRP) concentration, and white blood cell (WBC) count "were evaluated as markers of inflammation. Blood sugar and triglyceride concentrations were also measured, and 24-hour ambulatory ECG monitoring was conducted before HRV estimation. The findings indicated an inverse relationship between reported HRV and cigarette smoking, while a positive correlation was observed with physical activity.

(Karakaya et al., 2007) assessed the immediate impact of cigarette smoking on heart rate variability. This investigation examined the immediate impact on various parameters like Mean RR interval, SD of R-R interval, and the root mean square of the changes between subsequent R-R intervals, which were just some of the frequency and time domain metrics that were observed from all subjects for each 5-minute interval: Five minutes before smoking from all participants and for each 5-minute segment: 5 minutes before smoking and at the interval of five minutes, Ten minutes, Fifteen minutes, Twenty minutes and thirty minutes after smoking. These included the high-frequency, low-frequency ratio, and low-frequency/high-frequency ratio. The LF and HF exhibited a significant decrease within the first 5 minutes following

smoking and maintained a consistent level thereafter. In a similar manner, both HF and LF power exhibited an increase from the baseline value of individuals

(Mandolesi et al., 2018) Investigated the Effects of cigarette smoking on cardiac autonomic function during dynamic aerobic exercise. Also, fourteen healthy young smokers performed maximal exercise protocols and submaximal exercise protocols under control and smoking conditions. There are changes in the low frequency and ratio of HF/LF and VO2 max and peak performance, which were significantly reduced in cigarette smokers

(Unosson et al., 2013) examined the effect on heart rate, blood pressure, heart rate variability, and central arterial stiffness due to wood smoke in a cohort of fourteen healthy non-smoking adults. Subsequently, participants were randomly assigned to two distinct groups; one group was subjected to dilute wood smoke, while the other group was exposed to filtered air during periods of intermittent exercise. The results were assessed at the initial point and one hour following the exposure. The cardiovascular system was evaluated through the use of augmentation index, augmentation pressure, and pulse wave velocity, which exhibited an increase post-smoke exposure relative to inhalation of filtered air, accompanied by a rise in heart rate ($p \leq 0.01$). It was noticed that the HRV went down after smoking.

Samuel et al. (2016) investigated heart rate variability in healthy young volunteers as affected by smoking. A study was done on smokers and nonsmokers, where smokers were further divided into mild, moderate, and severe. An 8-channel Physio Pac of the Medicaid Company did a heart rate variability and found that mean RR, mean HR, and root mean square are insignificant between smokers and nonsmokers. However, other High Frequency (HF) values declined significantly in smokers, NN50, Pnn50, and the smokers show significantly higher low frequency (LF) and significantly higher LF/HF ratio when compared with the non-smokers.

2.6 Role of Exercise on Autonomic Function

(Kim et al., 2017) Examined the impact of aerobic training at different intensities and with different exercises on HRV in a group of chronic and habitual smokers consisting of 34 healthy males. Participants were allocated randomly to a moderate-intensity aerobic training group, which performed exercises at sixty percent of heart rate reserve, a high-intensity training group that functioned at seventy-five percent of HRR, or a control group. The HAT and MAT were conducted for eight weeks of aerobic training, three times a week, while all participants maintained their regular cigarette smoking habits. Heart rate variability was assessed to

determine the impact of aerobic training on autonomic regulation. The aerobic training, specifically HAT, enhances parasympathetic activity, resulting in improved HRV even in the presence of smoking.

(Richards et al., 2003)studied the effectiveness of aerobic exercise on the autonomic function and sympathetic and parasympathetic functions of the heart. Healthy, sedentary young adults were randomized and given 12 weeks of aerobic and strength training. Aerobic training is found to enhance the autonomic function, but with strength training, the autonomic function remains unaltered.

(Lee & Chang, 2013) performed the effect of smoking cigarette in female university students on the folling outcome measures aerobic capacity, anaerobic capacity, and heart rate variability. Twelve smokers and twenty-one non-smokers took part in the study. An intermittent sprint test and a 20-meter shuttle run were used to gauge each participant's anaerobic and maximal aerobic capacity. Participants were placed in the supine position for 20 minutes pre- and 30 minutes post-procedure, during which heart rate variability was monitored. As their maximal aerobic capacity dropped, female smokers experienced early exhaustion and a decline in average performance. Additionally, smoking increases sympathetic nerve activity while decreasing parasympathetic nerve activity.

Though ample literature exists, the role of exercise still needs to be looked at to find a simple and cost-effective method to improve autonomic functions in smokers.

CHAPTER III
METHODOLOGY

Chapter - 3

Methodology

The current study aimed to investigate the impact of smoking on their neurocognitive, pulmonary, and autonomic functions. Standardized protocols were employed throughout the study to assess neurocognitive, pulmonary, and autonomic function, measures in smokers and age-matched nonsmokers in Phase I. After this, smokers from Phase I with impaired neurocognition and pulmonary and autonomic dysfunction were enrolled for the study's aerobic and breathing group of Phase II. The results obtained from the study provide valuable insight into the positive impact of intervention, i.e., aerobic and breathing intervention, on all the measures of neurocognition and pulmonary autonomic function.

3.1 Study Area

Participants were smokers from the Tobacco Cessation Center of Manav Rachna International Institute of Research and Studies, Faridabad

3.2 Target Population

Phase I

The study involved individuals who have been smoking for the last 2 years and age-matched Non-Smokers

Phase II

The study involved individuals who have been smoking for the last 2 years with neurocognitive /pulmonary /autonomic dysfunctions.

3.3 Nature of Study

This Phase of the present study was an experimental study. This pre-post random design allows the evaluation and comparison of the efficacy of two exercise programs, i.e., Aerobic and breathing exercises, on neurocognition, pulmonary, and autonomic functions in smokers.

3.3 Participants

Phase I

The study enlisted a group of smokers who had been smoking for the last 2 years.

and age-matched nonsmokers

Phase II Individual from the first phase of the study, with either altered neurocognitive, pulmonary, or autonomic functions, who requires the presence of dysfunctions, constituted the study population for Phase II

3.4 Sample Size

Phase I

The minimum sample size required for the study has been based on the prevalence of smokers in India. For the same, from the WHO data, the prevalence of smoking among Indian adults was found to be 29%. Hence, by substituting in the formula mentioned below,

$n = Z\alpha^2 P (1 - P) / d^2$

Where n represents sample size, $Z\alpha$ is the statistic corresponding to the confidence level, i.e., $Z\alpha = 1.96$; P is the expected prevalence of smoking among the Indian adults (29%), and d is the margin of error, i.e., 5 % = 0.05.

. The total sample targeted was n=312

Phase II

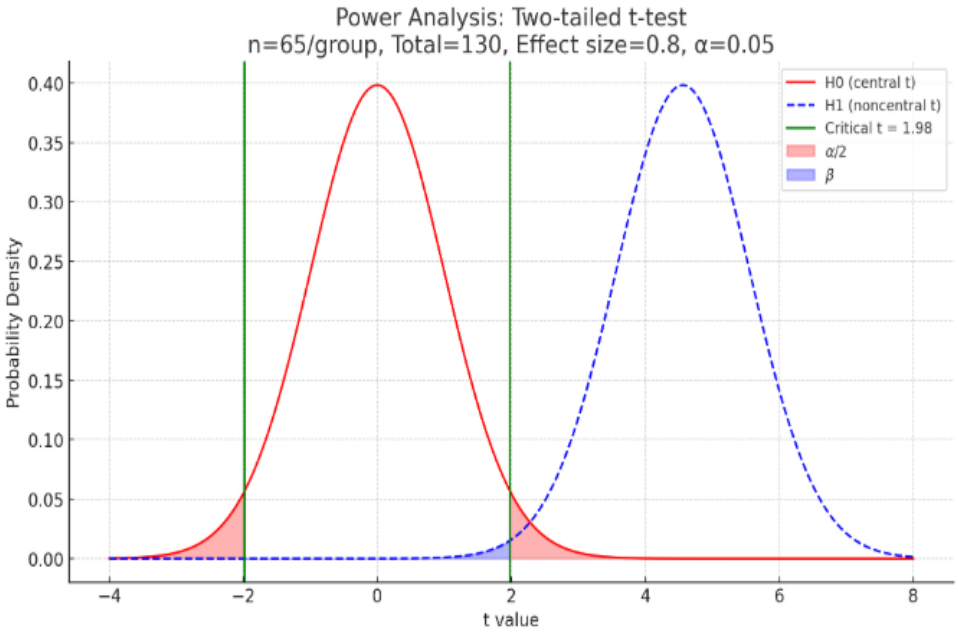


Figure 3.1 Sample calculation for Phase (Source: Self)

A total of 130 Smokers with autonomic/pulmonary/autonomic altered function were recruited for the study. Javadzadeh et al. (2021)

3.5 Sampling Technique

This study used a purposive sampling strategy to select a retrospective cohort of participants, all with a smoking habit and age-matched nonsmokers. This approach was chosen to ensure that the sample was directly linked to the research question, which seeks to assess the impact of smoking on neurocognition, pulmonary, and autonomic parameters.

After assessment of Smokers and nonsmokers in Phase I, smokers from Phase I with neurocognitive, pulmonary, and autonomic dysfunction are taken to Phase II of the study.

To enhance the study's internal validity and minimize the potential for selection bias, smokers selected from Phase I via purposive sampling were subsequently randomized into the Aerobic and Breathing Group. This random assignment was executed using a simple randomization technique, where participants were assigned to either group based on a random number generation method, ensuring each participant had an equal probability of assignment to each condition. This method of randomization helps achieve balance between the groups in terms of confounding variables that could affect the intervention outcome. The combination of purposive sampling and random assignment allows for a focused examination of the research question while maintaining the rigorous standards required for scientific inquiry.

Randomization, post-purposive selection, distributes any confounding factors evenly across the two groups, thereby allowing any differences observed in the outcomes to be more confidently attributed to the intervention itself rather than to underlying differences within the groups.

3.6 Ethical consideration and CTRI

Based on inclusion and exclusion criteria, smokers were recruited from the Tobacco Cessation Centre of Manav Rachna International Institute of Research and Studies.Participants received comprehensive information about the study, including its objectives, methodology, and potential risks. They were provided with an informed consent form detailing their rights as research subjects and were asked to sign it. Before starting work, ethical clearance was obtained from the institution's ethical committee, Manav Rachna International Institute of Research and Studies. The study was registered under CTRI no CTRI/2024/12/078331. All pertinent details on the consent form and the demographic/injury history questionnaire were safeguarded to ensure confidentiality by assigning a unique identifier to each participant

3.7 Criteria for the Selection of Sample

Phase I

3.7.1 Inclusion criteria:

1. Current smokers aged 30-50 years
2. Non-smokers aged 30-50 years
3. An individual willing to participate in the study

Phase II

3.7.2 Inclusion criteria:

1. Current smokers aged 30-50 years

2. Smoker with altered pulmonary, autonomic, and neurocognitive deficit ($\geq 50\%$ and $\leq 80\%$)/ Changes in autonomic functions (LF $\leq$500 Hz >1200 Hz and HF $\leq$300 Hz)**/MOCA scores less than 26/30)**

3.7.3 Exclusion criteria: (Phase I and Phase II)

1. Individuals suffering from other neurological or vestibular disorders.
2. Individuals with the presence of any peripheral vascular disease.
3. Individuals with psychosomatic disorder.
4. Persons performing Gym or involved in high-impact activity.
5. Non-cooperative individuals.
6. An individual using an assistive device for Walking.
7. Any other comorbidities interfering with Participation in the study.

3.8 Variables

Phase I

3.8.1 Independent Variables

(i). Smoking

3.8.2 Dependent Variable

(i). Neurocognitive Function

(ii).Pulmonary Function

(iii). Autonomic Function

Phase II

3.8.3 Independent Variables

(i). Aerobic Exercise

(ii).Breathing Exercise

3.8.4 Dependent Variable

(i). Neurocognitive Function

(ii). Pulmonary Function

(iii). Autonomic Function

3.9 Equipment(Phase I and Phase II)

(i). Weighing machine

(ii). Stadiometer

(iii). Sphygmomanometer

(iv). Polar Heart Rate Monitor

(v). MOCA test

(vi). Polar Heart monitor H10 with HRV module

(vii). Spirometer Medicaid

3.9 Procedure (Phase I)

Participants were selected from the tobacco cessation center and OPD at Manav Rachna International Institute of Research and Studies, and from the community outreach program by organizing camps. The participants were asked to sign a consent form after being briefed on the study's methodology and goals. Participants were then screened as per the selection criteria. At first, the participant's demographic data, such as age, height, weight, and BMI, was collected. Following this, MOCA assessed neurocognition, a spirometer assessed pulmonary function, and a heart rate variability device investigated autonomic functions.

Phase II

In this Present study, while the aerobic group consisted of 65 participants, the breathing group also started with 65 participants who underwent 5 weeks. Throughout the intervention, we observed regular dropouts in the experimental group, which is common in studies conducted on physical interventions. We employed a proactive recruitment strategy to mitigate the impact of these dropouts on the study's validity and ensure that we maintained the required sample size. As participants dropped out, we recruited new participants to join the experimental group. This approach allowed us to sustain the sample size at 65, ensuring the robustness of our findings and maintaining the study's statistical power.

3.10 Outcome Measures

3.10.1 Procedure for MOCA Assessment

The Montreal Cognitive Assessment (MoCA) is a standardized, brief screening tool developed to assess all cognitive function across various domains. It takes ten minutes to administer and evaluates several key cognitive domains, including memory, language, visuoconstructional skills, conceptual thinking, calculations, attention and concentration, executive functions, and orientation.

MoCA Tasks and Scoring Criteria

1. **Alternating Trail Making**

   A line connecting letters and numbers in alternating order (1-A-2-B-3-C-4-D-5-E) was to be

drawn by the subject. If the task was finished accurately, without mistakes or lines crossing, one point was given. Self-corrections made right away are accepted.

2. **Visuoconstructional Skills – Bed Copying**
   The subject was asked to copy a three-dimensional drawing of a bed. One point was awarded if all criteria were met: proper dimensionality, accurate lines, correct spatial orientation, and no extra lines.
3. The subject is instructed to draw a clock showing the time "10 past 5." Scoring includes three points across:

- **Contour**: The shape must be circular or square, with only minor imperfections allowed.
- **Numbers**: All 12 numbers must be present, ordered correctly, and positioned appropriately.
- **Hands**: Both minute and hour hands must be included, with the hour hand shorter and both centered.

4. **Naming**
   The subject was shown three animal images (e.g., horse, tiger, duck) and asked to name them. One point was awarded for each correct name.
5. **Memory – Immediate Recall**
   Five words were read twice. The subject attempts immediate recall after each reading. This section is not scored but is repeated later in the assessment as delayed recall.
6. **Attention and Working Memory**
   Forward Digit Span: The subject repeats a five-digit number in the same order.
   Backward Digit Span: The subject repeats a three-digit number in reverse order.
   Vigilance: The subject taps when hearing the letter "A" in a sequence. One point was awarded if there were zero or one errors.
   Serial 7s: The subject subtracts 7 repeatedly from 60. Three points are awarded based on the number of correct subtractions.
7. **Sentence Repetition**
   Two sentences were read aloud. The subject must repeat them exactly. One point was awarded per accurately repeated sentence.
8. **Verbal Fluency**
   Except for proper nouns and word variations, the subject has one minute to come up with as

many words as possible that start with a specific letter (for example, "B"). When 11 or more words are correct, one point was given.

9. **Abstraction**

   The subject identifies the category relationship between two items (e.g., hammer and screwdriver). One point was given for each correct abstract response, such as “tools” or “sources of light.”

10. **Delayed Recall**

    The subject was asked to recall the original five words presented during the memory task. One point was awarded for each word recalled spontaneously without cues. If recall fails, semantic and multiple-choice cues were offered to assist memory. These responses are recorded under the **Memory Index Score (MIS)** but do not contribute to the raw total.

11. **Orientation**

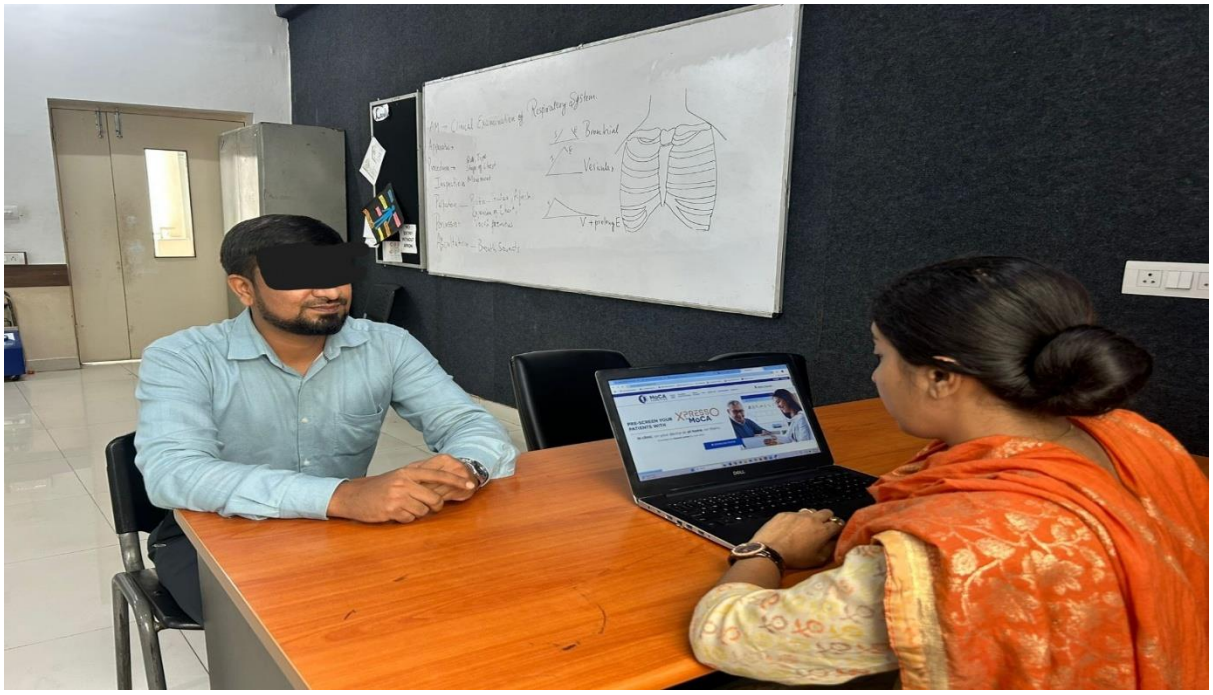
    The subject identifies the current date, day, month, year, location, and city. One point is awarded for each accurate response.

Scoring and Interpretation

The MoCA has a maximum score of 30. Individuals with 12 years or fewer of formal education receive one additional point. A score of 26 or above was considered within the normal range of cognitive functioning.

Reliability

The MoCA has demonstrated strong psychometric properties. Koski et al. (2013) reported a Cronbach’s alpha 0.71, indicating acceptable internal consistency. Cicchetti (1994) states that an intraclass correlation coefficient (ICC) of 0.75 or above reflects excellent test-retest reliability.



Photograph 3.1: Assessment of Neurocognitive functions of the participant

(Source: Self)

3.17.2 Procedure for assessing the pulmonary function test (PFT)

Spirometry is a fundamental physiological test to assess an individual's maximum inhalation and exhalation capacities. It provides quantitative measurements of both inspiratory and expiratory lung volumes, serving as a vital tool in the diagnosis, characterization, and severity assessment of respiratory disorders. In clinical practice, evaluating various lung volumes, "total lung capacity (TLC), functional residual capacity (FRC), residual volume (RV), and forced vital capacity (FVC)", is essential for accurate diagnosis and effective management of pulmonary conditions. Measurement of volumes helps in the evaluation and assessment of the disease's functional disability, severity, prognosis, and response to treatment, which is still unknown in infants, children, and adults. However, our study uses lung volume measurements to evaluate smokers' pulmonary function because they are strictly required for a proper physiological diagnosis. (Pellegrino and others, 2005). The primary signal measured in spirometry is either volume or flow as a function of time.

Instrument: The pulmonary function test in the current study will be measured using the **Medicaid Spirometer and Spiro Excel 1.1 desktop version**

Technique: When the patient puts the mouthpiece in their mouth, it was essential to ensure there are no leaks and that the patient is not blocking it. The following process was executed:

With a pause of less than one second at the full lung capacity, the patient inhales as much air as they can before breathing steadily for as long as they can until no air remains. Because of the low flow, air can leak out, so nose clips are crucial for VC.

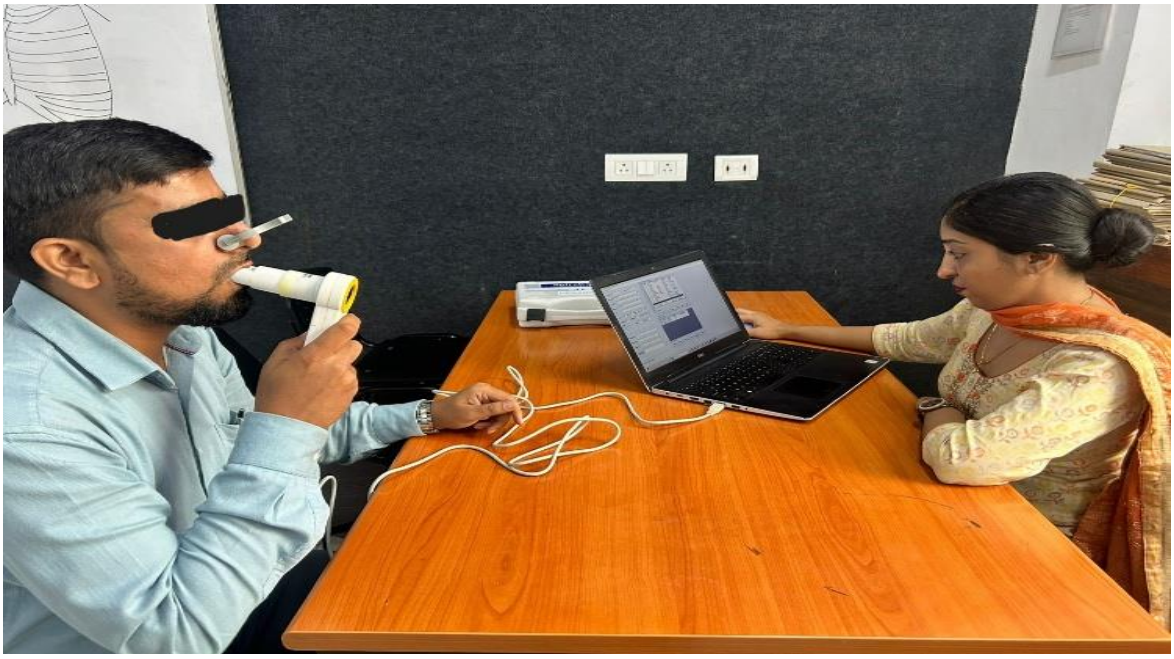
The maneuver has four phases-

. **The maneuver has four phases-**

1. Maximal inspiration: The subject was in a relaxed position, and was asked to inspire as deeply as possible".
2. Maximal expiration: After performing full inspiration, the subject was instructed to blow until the lungs felt completely empty. The patient should be prompted to "blast," not just "blow," the air from their lungs, and then they should be encouraged to expire fully. Subject continued complete expiration for a maximum of 15 seconds
3. The subject was instructed to inspire again after full expiration, maximally.

After completion of forced expiration, the patient was instructed not to remove the mouthpiece and rapidly inspire to full inflation. This measure of forced inspiratory (FIVC). **B**efore measurements were taken, participants were given precise pre-test instructions to reduce the likelihood of error and standardise the outcomes. They were told not to smoke for at least one hour before the test and not to drink alcohol for a minimum of four hours before the examination. All participants also requested that at least 30 minutes before the test, they did not perform vigorous physical exercise and did not wear tight or restrictive clothes that would restrict the complete expansion of the thorax and abdomen. They were also told not to consume a big meal within 2 hours before the spirometry test to prevent any effect on pulmonary function. All subjects were asked to sit comfortably for 5-10 minutes before the start of the test to bring the resting baseline.

Data recording: "Peak expiratory flow, forced expiratory volume in one second, forced vital capacity, and FEV1/FVC ratio were measured". The process was repeated every minute until two corresponding and satisfactory results were obtained.



Photograph 3.2: Assessment of Pulmonary Functions of Smokers

(Source: Self)

3.17.3 Procedure for Recording the Heart Rate Variability

The investigation was conducted to document the effect of smoking on the sympathetic and parasympathetic nervous systems, subsequently affecting the heart.

On the designated assessment day, participants were guided through a preparatory protocol to ensure the accuracy of HRV measurements. The measurements were for assessment of patient in Phase I taken before and after the 5 weeks of protocol. Participants were initially instructed to lie in a supine position—resting their backs on a couch—for a minimum of 10 minutes to promote complete relaxation, a crucial step for stabilizing heart rate variability (HRV). For male participants, care was taken to ensure optimal sensor signal quality by removing hair at the HR sensor placement site using a razor, followed by thorough skin cleansing and drying with sterile gauze. The assessment room was kept quiet and dimly lit, with the temperature maintained at 22°C to minimize sympathetic nervous system stimulation. Final skin preparation involved using non-alcoholic wipes to ensure the area was clean and dry before sensor attachment.

During the assessment, heart rate variability (HRV) data were collected using the **Polar H10 heart rate sensor belt**, known for its high precision in detecting R-R intervals. The sensor was securely fastened around the participant's chest, ensuring optimal skin contact for

accurate signal acquisition. Data were transmitted via Bluetooth to the **Elite HRV app**, which served as the primary platform for real-time monitoring and post-session analysis.

Participants remained in a supine position throughout the 5-minute recording period. They were instructed to wear the sensor continuously, avoid conversation, keep their eyes open to prevent drowsiness, minimize physical movement, and breathe naturally to maintain consistency in autonomic activity. To reduce the likelihood of signal artifacts, participants were asked to switch off mobile phones and remove metallic jewelry or smartwatches before the measurement.

The assessment environment was kept quiet and dimly lit, with the temperature maintained at 22°C to minimize sympathetic nervous system stimulation. The Elite HRV app automatically filtered out ectopic beats and movement artifacts using its built-in algorithms, ensuring the integrity of the HRV data. This preprocessing step is essential for the accurate interpretation of autonomic nervous system function.

Following data acquisition, the Elite HRV app provided detailed metrics including time-domain, frequency-domain, and non-linear HRV parameters. These metrics were used to assess the balance between sympathetic and parasympathetic nervous system activity, offering insights into the participant's physiological stress and recovery status.

The analysis concentrated on Heart Rate Variability indices in both the time-domain and frequency-domain. Time-domain measures, such as "Mean RR (average of normal-to-normal RR intervals), RMSSD (root mean square of successive differences between adjacent RR intervals), and SDNN (standard deviation of normal-to-normal RR intervals), were computed to assess HRV's temporal aspects. Frequency-domain indices, including TP (total power), LF (low-frequency spectral power), HF (high-frequency spectral power), and the LF/HF ratio", were examined to understand the autonomic nervous system's influence on cardiac function, especially the balance between sympathetic and parasympathetic activity.

Photograph 3.33: Assessment of Autonomic function of the participant

(Source: Self)

3.12 Intervention Group Aerobic Group

An aerobic training program was designed for Group A participants in line with the American College of Sports Medicine. 65 smokers were indulge in aerobic training where they were subjected to Moderate-intensity group for 30-60 min/day/week for 5 weeks, as per American College of Sports Medicine (ACSM) (Riebe, 2018). This training was divided into three phases: warm-up, main activity phase, and cool-down phase

Before Training, each participant's target heart rate was calculated on the following Basis.

"MHR = 220 - age. Was estimated using the formula, Maximum heart rate (MHR)

Target Heart Rate = [(max HR − resting HR) × %Intensity] + resting HR."

Warm-up phase

The warm-up phase of aerobic exercises lasted 5 minutes and consisted of exercises.

Stretching exercise

Stretching exercise

Adductor stretches. The participant sits on the floor with one leg extended straight out. The opposite leg is bent, with the sole placed against the inner thigh of the extended leg. From this position, they were instructed to gently reach forward toward the toes of the straight leg, maintaining the stretch. ***10 repetitions,1 set**

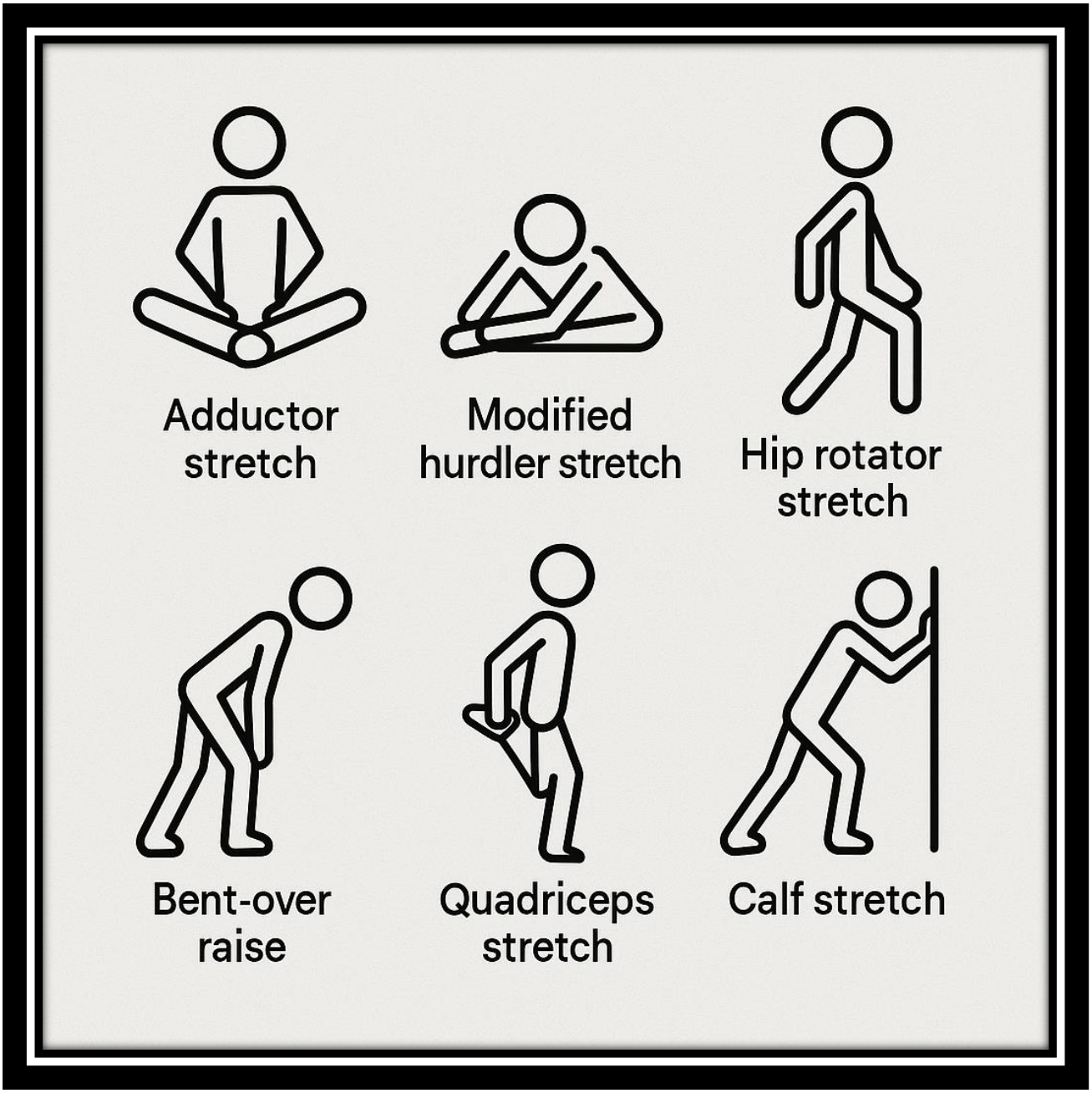
Modified hurdle stretch. "While seated, the individual extends one leg forward and bends the opposite leg, placing the sole against the inner thigh of the extended leg. From this position, they are guided to slowly lean forward, reaching toward the toes of the straight leg. ***10 repetitions,1 set**

Hip rotator stretch. "In a seated position, the individual crosses one leg over the opposite thigh to form a figure-four shape. They then gently pull the uncrossed leg toward the chest, flexing both hips to approximately 90 degrees or more." ***10 repetitions,1 set**

Bent over to raise. While standing, the individual positions one foot slightly ahead of the other, so that the heel of the front foot is just in front of the toes of the back foot. They then dorsiflex the front foot—pulling the toes toward the shin—while gently leaning the upper body forward over the front leg." ***10 repetitions,1 set**

Quadriceps stretch. While standing upright with the spine straight, the individual bends one knee and brings the heel toward the buttocks. Using one hand, they gently hold the ankle or foot to maintain the stretch." ***10 repetitions,1 set**

Calf stretch. "In a standing position, the individual places their feet in a staggered stance, about 2 to 3 feet away from a wall. With both hands pressing against the wall for support, they keep the back leg straight and the front knee slightly bent while leaning forward into the stretch." ***10 repetitions,1 set (Picture 1 Represent all positions for Warm up)**

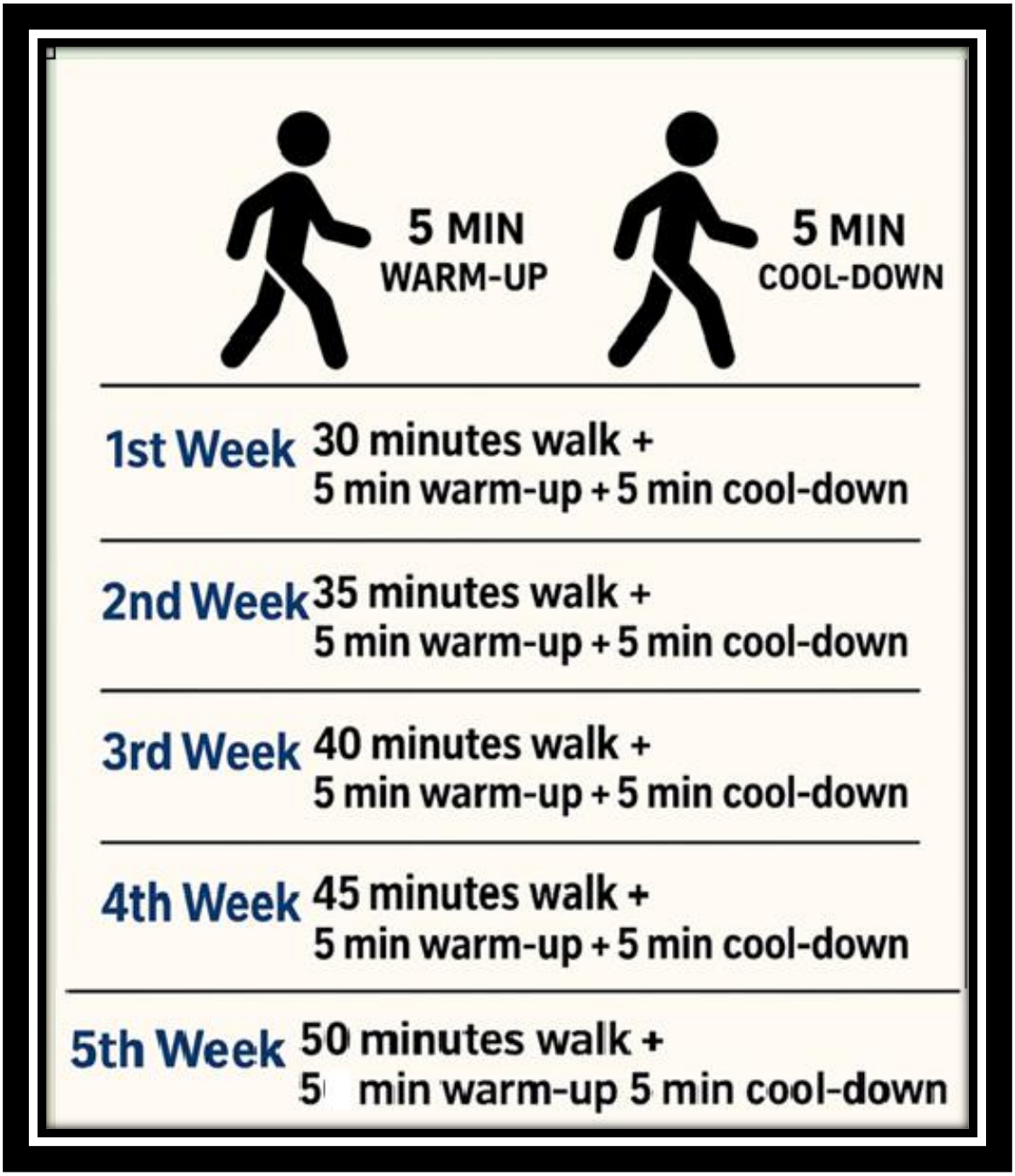


Picture 1- Represent Warm phase exercises for the Aerobic group

Aerobic Exercise Phase

Subjects were instructed to start walking and maintain a maximum heart rate between 65 and 75 percent of their maximum heart rate. The patient was instructed to report any breathlessness during the session. A heart rate monitoring device is attached to maintain the heart rate in range. Progression is done depending on the FITT principle (Table 3.1). Progression of Aerobic exercises Picture 2

Cool Down Phase The Cool down phase consists of light jogging for 2 minutes, followed by walking for 3 minutes at their own pace, but always less than the main activity phase


5 MIN
WARM-UP
5 MIN
COOL-DOWN
1st Week 30 minutes walk +
5 min warm-up + 5 min cool-down
2nd Week 35 minutes walk +
5 min warm-up + 5 min cool-down
3rd Week 40 minutes walk +
5 min warm-up + 5 min cool-down
4th Week 45 minutes walk +
5 min warm-up + 5 min cool-down
5th Week 50 minutes walk +
5 min warm-up 5 min cool-down

Picture 2- Pictorial representations of the Aerobic group intervention

Table 3.1: Aerobic Exercise

Sno	Duration and Speed of walk	Total duration per week
1st week	30 minutes *5 times a week with 5 minutes warm-up and cool-down	150min/week
2nd week	35 minutes *5 times a week with 5 minutes warm-up and cool-down	175 min/wk
3rdweek	40 minutes *5 times a week with warm-up and cool-down	200 min/wk
4th week	45 minutes *5 times a week with warm-up and cool-down	225 min/wk
5th week	50 minutes *5 times a week with warm-up and cool-down	250 min/wk

(Source: Self)

Photograph 3.4: Subject performing Aerobic Training (Source: Self)

Breathing exercise group

A breathing training program was designed for Group B participants in line with Donna Fowleter's breathing protocol. Sixty-five smokers in the breathing exercise group were divided into three phases: warm-up, breathing phase, and cool-down phase.

Warm-up Phase

Stretching exercise

Adductor stretches. The participant sits on the floor with one leg extended straight out. The opposite leg is bent, with the sole placed against the inner thigh of the extended leg. From this position, they were instructed to gently reach forward toward the toes of the straight leg, maintaining the stretch. ***10 repetitions,1 set**

Modified hurdle stretch. "While seated, the individual extends one leg forward and bends the opposite leg, placing the sole against the inner thigh of the extended leg. From this position, they are guided to slowly lean forward, reaching toward the toes of the straight leg. ***10 repetitions,1 set.**

Hip rotator stretch. "In a seated position, the individual crosses one leg over the opposite thigh to form a figure-four shape. They then gently pull the uncrossed leg toward the chest, flexing both hips to approximately 90 degrees or more." ***10 repetitions,1 set**

Bent over to raise. While standing, the individual positions one foot slightly ahead of the other, so that the heel of the front foot is just in front of the toes of the back foot. They then dorsiflex the front foot—pulling the toes toward the shin—while gently leaning the upper body forward over the front leg." ***10 repetitions,1 set**

Quadriceps stretch. While standing upright with the spine straight, the individual bends one knee and brings the heel toward the buttocks. They gently hold the ankle or foot using one hand to maintain the stretch." ***10 repetitions,1 set**

Calf stretch. "In a standing position, the individual places their feet staggered, about 2 to 3 feet away from a wall. With both hands pressing against the wall for support, they keep the back leg straight and the front knee slightly bent while leaning forward into the stretch." ***10 repetitions,1 set**

Breathing Exercises

Allocated smokers in Group B undergo structured breathing exercises in three phases.

Breathing Control

Diaphragmatic Breathing .

Pursed Lip Breathing

Breathing control: The patient was told to use their normal tidal volume and breathe relaxedly. While the lower chest and abdomen should be active, the upper chest and shoulders should be kept in a relaxed position. The breathing control phase should continue for as long as the patient needs to unwind and prepare for the subsequent stages, typically five to ten seconds. Place your hand on the patient's abdomen at the level of the umbilicus, explaining to them that you want to feel his or her breathing. Follow the patient's breathing pattern for a few cycles to get into breathing rhythm. Before invading the patient's breathing pattern, rather, at first, follow their movement.

In pursed lip breathing, the smoker was asked to inhale through the nose and exhale through pressed lips in the shape of a pursed lip opening. Then, the smokers were asked to place one hand over the chest and the other below the rib cage. They were asked to feel the in and out movements of the stomach as they inhale and exhale. Once they get their rhythm

of breathing, they are asked to provide pressure through their hands below the rib cage. These steps were involved in the diaphragmatic breathing exercise.

Finally, they were asked to take a deep inhale with the assistance of both their upper limbs rising overhead and a deep exhale with the assistance of both their upper limbs lowering towards the ground. This type of breathing will be considered a deep breathing exercise (Abid et al., 2020)

Three distinct conditions were then recorded: (1) participants' breathing control, which consisted of six minutes of quiet breathing in three sets of two minutes each; (2) diaphragmatic breathing in three sets of two minutes each; and (3) diaphragmatic breathing plus pursed-lips breathing in three sets of two minutes each. (Cahalin and others, 2002)Table 3.2, Picture 2

Table 3.2: Intervention for Breathing Group

Breathing Exercises progressed according to the Principle and Practice of Cardiopulmonary Donna Fownfelter.

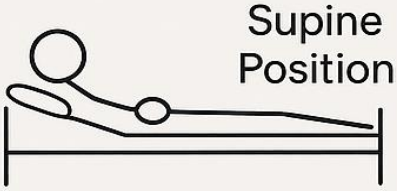
Weeks	Technique	Total duration per week
1st week	6 minutes of Breathing control +6 min Diaphragmatic Breathing +6 min Diaphragmatic plus and Pursed lip Breathing in **semifowler Position**	3 sets of 2 min Breathing control 3 sets 2 min Diaphragmatic Breathing 3 sets 2 min Diaphragmatic Breathing along with Pursed Lip Breathing * 2 times a day
2nd week	6 minutes of Breathing control +6 min Diaphragmatic Breathing +6 min Diaphragmatic plus and Pursed lip Breathing in **Supine Position**	3 sets of 2 min Breathing control 3 sets 2 min Diaphragmatic Breathing 3 sets 2 min Diaphragmatic Breathing along with Pursed Lip Breathing * 2 times a day
3rdweek	6 minutes of Breathing control +6 min Diaphragmatic Breathing +6 min Diaphragmatic plus and Pursed lip Breathing in **Standing**	3 sets of 2 min Breathing control 3 sets 2 min Diaphragmatic Breathing

		3 sets of 2 min Diaphragmatic Breathing along with Pursed Lip Breathing * 2 times a day
4th week	6 minutes of Breathing control +6 min Diaphragmatic Breathing +6 min Diaphragmatic plus and Pursed lip Breathing in **Walking**	3 sets of 2 min Breathing control 3 sets 2 min Diaphragmatic Breathing 3 sets of 2 min Diaphragmatic Breathing along with Pursed Lip Breathing * 2 times a day
5th week	6 minutes of Breathing control +6 min Diaphragmatic Breathing +6 min Diaphragmatic plus and Pursed lip Breathing in **Stair climbing**	3 sets of 2 min Breathing control 3 sets of 2 min Diaphragmatic Breathing 3 sets of 2 min Diaphragmatic Breathing along with Pursed Lip Breathing * 2 times a day

5 minutes warm up

Semi-Fowler Position

- Breathing control (6 min
- Diaphragmatic Breathing (6 min

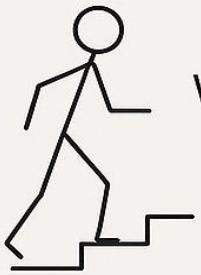


Supine Position

- Breathing control (6 min
- Diaphragmatic Breathing (6 min

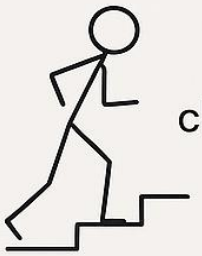
Standing

- Breathing control (6 min
- Diaphragmatic Breathing (6 min



Walking

- Breathing control (6 min
- Diaphragmatic Breathing (6 min



Stair climbing

- Breathing control (6 min
- Diaphragmatic Breathing (6 min

5 minutes cool down

5 minutes cool down	5 minutes cool down

Picture 3- Pictorial representations of the Breathing group

(a)

(b)

Photograph 3.5(a) Subject performing Breathing training in semi-Fowler's position.
Photograph 3.5: (b)Subject performing Breathing training in Sitting position

(c)

Photograph 3.3(c)Subject performing Breathing training in Sitting position (Source: Self)

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